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A behavioural approach to specifying interventions: what insights can be gained for the reporting and implementation of interventions to reduce antibiotic use in hospitals?

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Background: Reducing unnecessary antibiotic exposure is a key strategy in reducing the development and selection of antibiotic-resistant bacteria. Hospital antimicrobial stewardship (AMS) interventions are inherently complex, often requiring multiple healthcare professionals to change multiple behaviours at multiple timepoints along the care pathway. Inaction can arise when roles and responsibilities are unclear. A behavioural perspective can offer insights to maximize the chances of successful implementation.

Objectives: To apply a behavioural framework [the Target Action Context Timing Actors (TACTA) framework] to existing evidence about hospital AMS interventions to specify which key behavioural aspects of interventions are detailed.

Methods: Randomized controlled trials (RCTs) and interrupted time series (ITS) studies with a focus on reducing unnecessary exposure to antibiotics were identified from the most recent Cochrane review of interventions to improve hospital AMS. The TACTA framework was applied to published intervention reports to assess the extent to which key details were reported about what behaviour should be performed, who is responsible for doing it and *when*, *where*, *how often* and *with whom* it should be performed.

Results: The included studies ($n = 45$; 31 RCTs and 14 ITS studies with 49 outcome measures) reported *what* should be done, *where* and *to whom*. However, key details were missing about *who* should act (45%) and *when* (22%). Specification of *who* should act was missing in 79% of 15 interventions to reduce duration of treatment in continuing-care wards.

Conclusions: The lack of precise specification within AMS interventions limits the generalizability and reproducibility of evidence, hampering efforts to implement AMS interventions in practice.

Introduction

Reducing unnecessary exposure to antibiotics in hospitals is a key strategy in reducing the development, selection and spread of antibiotic-resistant bacteria.[1]

Many hospitals around the world have implemented antimicrobial stewardship (AMS) programmes involving a multidisciplinary AMS team and a systematic approach for actions to improve responsible/appropriate antibiotic use.[2] Establishing which interventions are most effective in reducing antibiotic exposure is an important first step towards improving antibiotic prescribing. However, identifying AMS interventions that have been successful in one setting is not enough to ensure effective AMS interventions will be effectively implemented more widely in hospitals.

The Cochrane review of interventions to improve antibiotic prescribing to hospital inpatients provides clear evidence that AMS interventions can increase compliance with antibiotic policy.[3] There were 221 included studies in the review, with the majority focusing on choice, route or dose of antibiotic medicines. There was high-certainty evidence from randomized controlled trials (RCTs) that AMS interventions can reduce the total duration of antibiotic treatment and evidence from interrupted time series (ITS) studies provided additional evidence that the results of AMS interventions are reproducible in routine practice.[3] The aim of this review is to use a behavioural perspective to examine the AMS interventions in these RCTs and ITS studies from the Cochrane review and to make recommendations about the application of behaviour-change principles to the design and reporting of future interventions.

Hospital AMS interventions are inherently complex, often requiring multiple healthcare professionals to change multiple behaviours at multiple timepoints along the care pathway. Inaction can arise when roles and responsibilities are unclear. Effective AMS interventions are more likely to be interpretable, reproducible and implemented if it is clearly specified *what* behaviour(s) should be performed, *who* is responsible for doing it and *when*, *where*, *how often* and *with whom* it should be performed.[4,5] Specifying behaviour in this way is known as the TACTA framework: Target (patient group, e.g. elective surgery patients), Action (start or stop antibiotics), Context (specific hospital ward, e.g. surgical ward), Timing (when to start or stop, e.g. 24 h after surgery) and Actors (healthcare professionals responsible for the action, e.g. the surgeon who performed the operation).[6] Poor specification of behaviour creates difficulties for research (hampering interpretation of results, replication of interventions and studies, and evidence synthesis) and practice (impeding replication, scaling up and implementation of effective AMS interventions into clinical settings). Applying TACTA to ensure precise specification of problems and recommendations makes implementation more feasible; it provides greater clarity about what is required and greater certainty about whether it has been accomplished.[6,7]

Our aim in this study was to apply this framework that guides specification of behaviours to evidence from the Cochrane review about interventions focused on reducing unnecessary exposure to antibiotics[3] in order to determine the extent to which stewardship interventions are currently specified in key behavioural elements and thereby explore what insights can be gleaned for efforts to implement AMS interventions in hospitals.

Methods

Study selection

For this review, we included relevant studies from the 196 RCTs and ITS studies included in the Cochrane review of interventions to improve antibiotic prescribing to hospital inpatients.[3] Detailed methods of the Cochrane review are reported elsewhere[3] and Figure 1 provides a diagram of study flow for this review. Studies were included if the prescribing outcome was coded by the original Cochrane review team as a decision to start or stop antibiotics, with the intervention target to reduce exposure. We excluded studies if the target was to increase antibiotic exposure as focusing on reducing unnecessary exposure to antibiotics in hospitals is a key strategy in reducing the development and selection of antibiotic-resistant bacteria.

Data extraction

Two authors (E.M.D. and P.G.D.) reviewed the full text of each included study. We separated the studies into those based in ICUs versus continuing-care wards because ICUs have higher staffing levels with daily rounds by senior medical staff.[8] In contrast, prescribing decisions in continuing-care wards are more likely to be made by doctors-in-training and there is increasing evidence about the complex social and professional dynamics underlying their prescribing decisions.[9–11] In the Cochrane review, 51% of interventions were coded as designed and delivered by a multidisciplinary Antimicrobial Management Team of physicians working with pharmacists and/or nurses.[3] Details of the AMS interventions were extracted verbatim from the original studies. Effective Practice and Organisation of Care (EPOC)

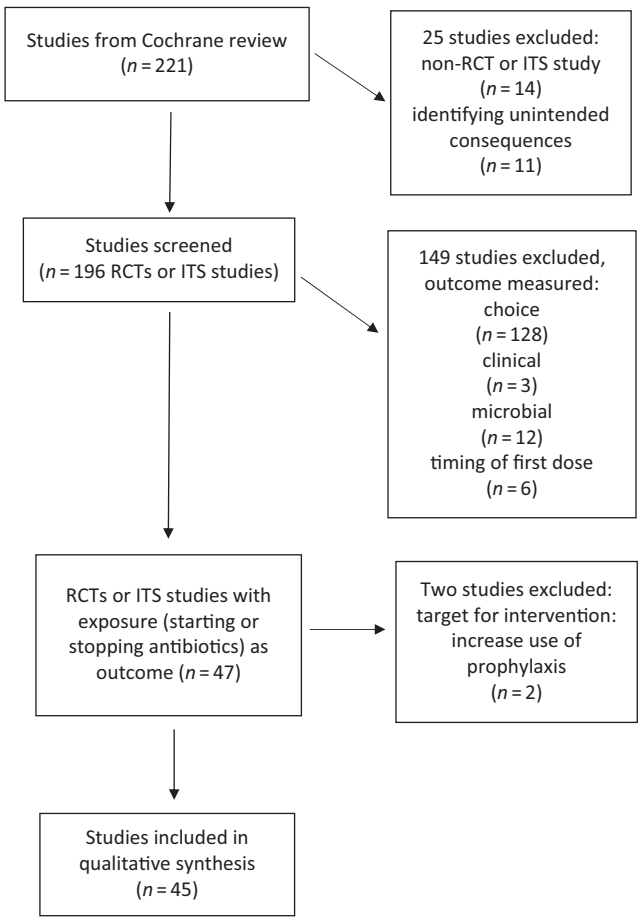

Figure 1. Study flow diagram.

intervention categories were included based on the original Cochrane review coding.[3]

Behavioural specification

The TACTA framework[6] was used to specify verbatim descriptions of the interventions in terms of Target (patient group), Action (start or stop antibiotics), Context (specific hospital ward), Timing (when to start or stop) and Actors (healthcare professionals responsible for the action). Two authors (E.M.D. and P.G.D.) independently coded interventions and then compared coding. Two additional authors (J.J.F. and F.L.) reviewed the final coding. Differences in coding of each element were resolved by discussion.

Results

Details of included studies

The 45 included studies were 31 RCTs and 14 ITS studies and reported on 49 outcomes of AMS interventions (4 studies reported 2 outcomes for their interventions[12–15]). Details of individual studies are given in Tables S1 to S4 (available as Supplementary data at *JAC* Online): country; number of hospitals; context; target patients; intervention; action; timing; actors; and outcome. The most represented country setting was the USA (12 studies), followed by Switzerland (10 studies). Most studies were conducted in a single country setting, but one was carried out across five countries.[16] The maximum number of hospitals within a single study was 41.[17] There were 15 interventions to reduce the number of patients who started antibiotics (Table S1), 4 to reduce duration of antibiotic prophylaxis (Table S2) and 30 to reduce duration of antibiotic treatment; 16 in ICUs (Table S3) and 14 in continuing-care wards (Table S4). Four RCTs[12–15] measured the effect of an intervention both on reducing the number of patients who started antibiotics and on the duration of treatment in patients who started antibiotics.

Five of the EPOC intervention categories[18] are reflected in the included studies: (i) educational outreach through review and recommendation for change; (ii) audit and feedback about compliance with policies; (iii) dissemination of educational materials; (iv) reminders; and (v) structural interventions. In addition, one study included a restrictive intervention.[19]

Defining clinical behaviours with TACTA

The application of the TACTA framework to coding AMS interventions is demonstrated for two studies[20,21] in Table 1 as examples. Both studies were intended to reduce the duration of antibiotic prophylaxis for adults undergoing elective surgery. However, there were important differences with respect to actions, timing and actors (Table 1). Both studies included AMS interventions with explicit assignment of responsibility for stopping antibiotics to the surgeon (actor). However, in one of these studies[20] the action was supported by introducing a default order for prophylactic antibiotics to stop after 24 h and by making pharmacists responsible for review of patients to ensure that antibiotics had been stopped. Both studies used an ITS design and the results show different effects of the AMS interventions over time (Figure 2). Both studies improved performance, but did not reach the target of 95% reliability in the first 6 months after the AMS interventions started. However, in one of the studies[20] changes were made to the intervention over time; the Surgical Infection Prevention Team noted remaining room for improvement and went to the Pharmacy and Therapeutics Committee to request that it approve an automatic stop on prophylactic antibiotics after 24 h (48 h for cardiothoracic procedures). Following this approval, pharmacists automatically stopped administration of prophylactic antibiotics ordered for more than 24 or 48 h and this was associated with sustained improvement to 95% reliability.[20] In contrast, there was no change in the intervention in the other study and the process was still only 60%–70% reliable at 10–12 months post-intervention (Figure 2).[21]

Table 1. Examples of TACTA specification of behaviour for two studies of interventions intended to reduce duration of antibiotic prophylaxis after surgery

TACTA domain	Dull *et al.*[20] (2008)	Sun *et al.*[21] (2011)
Target	adults undergoing elective surgery: coronary artery bypass graft (CABG); other cardiac surgery; hip arthroplasty; knee arthroplasty; colorectal surgery; hysterectomy; and vascular surgery	adults undergoing elective surgery: CABG
Action	stop antibiotics	stop antibiotics
Context	surgical wards in two hospitals in the USA	cardiac surgery ward in one hospital in Taiwan
Timing	24 h after surgery (48 h after cardiac surgery)	24 h after surgery
Actors	surgeon who performed the operation and pharmacists	cardiac surgeon

When the TACTA framework was applied to all studies we found that the action, context and target patients were always specified, but specification of timing and actors was more variable (Table 2).

Actions

Action was specified across all studies included in this review and three actions were apparent: (i) starting antibiotics; (ii) stopping prophylactic antibiotics; and (iii) stopping therapeutic antibiotics.

Starting antibiotics

Fifteen studies evaluated interventions relating to starting, or not starting, antibiotics (Table 2; further details in Table S1). In 12 of these, the AMS intervention was a reminder linked to a laboratory test result: procalcitonin in 9 studies,[12–15,22–26] rapid microbiology diagnostic test for viruses or atypical bacteria in 2 studies[27,28] and IL-8 in 1 study.[16] In three studies, the AMS intervention was the introduction of a guideline about management of bronchiolitis,[17,29,30] with audit and feedback in two of these studies.[29,30]

Stopping prophylactic antibiotics

There were four ITS studies of AMS interventions to reduce duration of prophylactic antibiotics in adult surgical patients (Table 2;

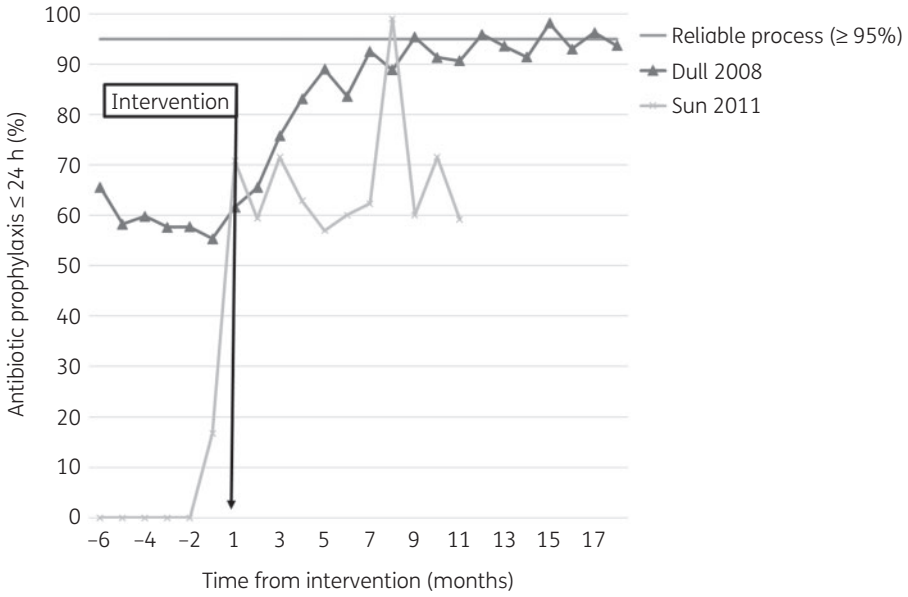

Figure 2. Intervention effect over time for two studies that aimed to increase the percentage of patients who received surgical antibiotic prophylaxis for ≤24 h. Drawn from data reported by Dull *et al.*[20] (2008) and Sun *et al.*[21] (2011).

Table 2. Number of studies that specified target, action, context, timing and actors

Action	Context	Studies (design)	Target patients	Timing	Actors
Starting antibiotics	emergency department	9 (6 RCT[12,13,22,25,26,28], 3 ITS[17,29,30])	8 community-acquired LRTI, 1 fever	9 on admission	3 resident, supervised, 3 treating physician, 3 not clear
	ward	6 (6 RCT[14–16,23,24,27])	3 community-acquired LRTI, 1 acute exacerbation of asthma, 1 community-acquired fever in neonates, 1 post-cardiac surgery	5 on admission, 1 after surgery	5 treating physician, 1 physician in charge
Stopping prophylactic antibiotics	operating theatre	2 (2 ITS[31,32])	2 elective surgery	2 at start of operation	2 not clear
	surgical ward	2 (2 ITS[20,21])	2 elective surgery	2 at 24 h post-operative	1 pharmacist and surgeon, 1 surgeon
Stopping therapeutic antibiotics	ICU	16 (14 RCT[19,33–45], 2 ITS[46,47])	8 sepsis, 5 hospital-acquired LRTI, 3 all on antibiotics	9 multiple (e.g. daily) reviews, 2 single review (e.g. at 48–72 h), 5 not clear	6 treating physician, 2 physician in charge, 1 one of four ICU consultants, 1 AMT member, 6 not clear
	ward	14 (9 RCT[12–15,49,51,55–57], 5 ITS[48,50,52–54])	6 all on antibiotics, 5 community-acquired LRTI, 1 positive blood cultures, 1 acute pancreatitis, 1 acute exacerbations of pulmonary fibrosis	3 multiple (e.g. daily) reviews, 5 single review (e.g. at 48–72 h), 6 not clear	3 treating physician, 11 not clear

LRTI, lower respiratory tract infection; AMT, Antimicrobial Management Team.
Note that the total number of studies is 49 because 4 RCTs[12–15] measured the effect of an intervention on two actions (starting and stopping antibiotic treatment) with different outcome measures for each action.

further details in Table S2). The interventions were audit and feedback in three studies[20,21,31] and a new guideline in one.[32]

Stopping therapeutic antibiotics

There were 16 studies of AMS interventions to reduce duration of antibiotic treatment in ICUs (Table 2; details in Table S3), introduction of procalcitonin testing in 11 studies,[33–43] review of prescribed antibiotics by members of the AMS team in 4 studies[19,44–46] and introduction of a new guideline in one study.[47] There were 14 studies of AMS interventions on duration of antibiotic treatment in inpatient wards (Table 2; details in Table S4), including review and recommendation for change by a member of the AMS team in 5 studies,[48–52] antibiotic guidelines in 2 studies[53,54] and rapid microbiology testing in 1 study.[55] Procalcitonin featured in six studies.[12–15,56,57]

Context

Context was specified across all the studies included in this review and included emergency departments (in 9 studies), operating theatres (in 2 studies), surgical wards (in 2 studies), ICUs (in 16 studies) and wards (in 20 studies).

Target

The target patients for AMS interventions were specified across all the studies and included patients with community-acquired lower respiratory tract infection (in 16 studies), all patients (in 9 studies), patients with sepsis (in 8 studies), patients with hospital-acquired lower respiratory tract infection (in 5 studies), elective surgical patients (in 4 studies), patients with fever (in 1 study), neonatal patients with community-acquired fever (in 1 study), post-cardiac surgical patients (in 1 study), patients with positive blood cultures (in 1 study), patients with acute pancreatitis (in 1 study) and patients with acute exacerbations of pulmonary fibrosis (in 1 study).

Timing

Overall, the timing of when an intervention should occur was specified in 76% of studies. Timing was specified for all interventions that targeted starting antibiotics or stopping prophylactic antibiotics. However, timing of interventions to stop therapeutic antibiotic treatment was specified for only 11 (69%) of 16 studies in ICUs and 7 (50%) of 14 studies in wards (Table 2).

Actors

Overall, the actor of an intervention was specified in 55% of the studies. Actors were specified for 12 (80%) of 15 AMS interventions targeted at starting antibiotics, but only for 2 (50%) of 4 AMS interventions targeted at stopping prophylactic antibiotics. Actors were specified in 10 (63%) of 16 ICU studies and 3 (21%) of 14 ward studies where AMS interventions were to stop antibiotic treatment (Table 2). Three of the interventions targeted at starting antibiotics specified that the actor was a resident who was supervised by a senior physician[12,13,22] and two of the interventions targeted at stopping antibiotics in ICUs specified that the actor was one of four ICU consultants[46] or the member of the Antimicrobial Management Team (AMT) who reviewed the patient.[19] In contrast, several studies specified actors as either the 'treating physician' or 'physician in charge' (Table 2), terms that do not clarify the role of junior and senior doctors or the clinical speciality.

Summary of results

When the TACTA framework was applied to all studies we found that the action, context and target were always specified. Emergency departments were the context for 60% of interventions targeting patients who start treatment and ICUs were the context for 56% targeting duration of treatment. Procalcitonin was the most common AMS intervention overall. Specification of timing and actors was less reliable, particularly for AMS interventions targeting antibiotic treatment in wards.

Discussion

The key finding in this review is that studies did not consistently report the actor (who is responsible) and timing (when to start/stop antibiotics), whilst target (patient group), action (what should be done) and context (where, e.g. ward or unit) were always specified. Decision-making about antimicrobial use in hospitals is a complex process, which can involve one or more actors and be influenced by cultural factors such as etiquette and hierarchy.[58–61] Few AMS interventions included in this review specified more than one actor and only one specified an actor who was not a doctor,[20] which fails to reflect the multi-professional care-delivery system of antibiotics in hospitals.[9,10,62–65]

Defining clinical behaviours with the TACTA framework

The first step in a behavioural approach to designing (and reporting) interventions is to define the problem in behavioural terms: who needs to do what differently to whom, where and when? The second step is to identify and prioritize a range of potential target behaviours.[4] Poor specification of the target behaviour, as this review has found for AMS interventions, causes problems for both research (creating difficulties for interpreting results, replication of interventions and studies, and evidence synthesis) and practice (impeding replication, scaling up and implementation of effective AMS interventions into clinical settings). Two of the AMS interventions to stop prophylactic antibiotics identified the surgeon as an actor for their intervention and made them specifically responsible for the action[20,21] (Table 1). Both interventions improved performance, but did not reach the target of 95% reliability within 6 months. In one study the AMS intervention was revised, which was associated with sustained improvement to 95% reliability[20] (Figure 2). Iterative review should be the rule rather than the exception in behaviour-change interventions, with revision of the intervention if it is not achieving its goal or if it has unanticipated, unpleasant consequences.[66–68] However, the study by Dull *et al.*[20] was the only example, among 45 included studies, of review and revision of an intervention through identification of additional actors.

In comparison with stopping therapeutic antibiotics, changing behaviour to stop prophylactic antibiotics may be more straightforward for two reasons. First, there is compelling evidence that stopping prophylactic antibiotics after 24 h does not increase risk of surgical site infection and that continuing antibiotics for >24 h is

likely to increase risk of *Clostridioides difficile* infection,[69] which can be used to influence prescribers' motivation through beliefs about consequences. Second, the patients are undergoing elective surgery, which facilitates the opportunity to clearly identify both the target and the actors for the intervention.

All of the included studies described the physical context for the intervention as either ICUs or continuing-care wards (Table 1). In ICUs, daily rounds by senior doctors are the norm[8] and most AMS programmes already include review by infection specialists.[2,70,71] In contrast, in continuing-care wards, regular review of patients is often done by doctors-in-training, supported by less frequent ward rounds by senior doctors.[9–11,61] A realist review of evidence from 131 studies found that doctors-in-training operate within challenging contexts (hierarchical relationships, powerful prescribing norms, unclear roles and responsibilities) where they prioritize particular responses due to fear of criticism and fear of individual responsibility for patients deteriorating.[11] The authors conclude that these complex dynamics explain how and why doctors-in-training follow senior clinicians' prescribing habits, take into account advice from other health professionals, ask questions or challenge decisions.[11] Furthermore, two recent qualitative studies found that the social context in which doctors-in-training work can be very different in medical and surgical wards.[58,61] There is already evidence about differences in professional identity and culture between medicine and surgery, but these studies demonstrate the need for a thorough understanding of specialty-specific norms surrounding antimicrobial prescribing.[72]

Only three of our included studies explicitly identified doctors-in-training as actors and described their supervision by senior colleagues.[12,13,22] All three of these studies were from emergency departments. In contrast, of the five studies of AMS interventions to stop antibiotics in continuing-care wards through review by a member of the AMS team, only two identified an actor for the recommendation and both of these were ambiguous. Recommendations through 'direct interaction with the prescribing physician'[51] or through communication 'to the clinician caring for the child'[52] could be interpreted as either for the junior doctor who wrote the prescription or reviews the patient regularly, or as the senior doctor who is responsible for the patient. In the remaining three studies, the recommendation was entered into the medical record[48,49] or was communicated 'by telephone, through the electronic medical record or on rounds'[50] so it was not clear who was expected to act on the recommendation.

Hospital AMS interventions focused on reducing exposure to antibiotics

Procalcitonin was the most common intervention focused on exposure overall, accounting for half of the studies targeting patients who start antibiotics on admission to hospital and the duration of therapeutic antibiotics in wards (Table S1), with the majority of studies targeting duration of therapeutic antibiotics in ICUs (Table S3). In 2015, NICE issued guidance on procalcitonin testing for two indications: stopping antibiotic treatment in people with confirmed or highly suspected sepsis in the ICU, or starting and stopping antibiotic treatment in people with suspected bacterial infection presenting to the emergency department.[70] The guidance was based on evidence from a systematic review of 18 studies, which included 12 RCTs from our review.[12,13,15,25,26,33,34,36–38,43,57] NICE did not recommend adoption of procalcitonin because the control arm in these RCTs did not reflect current standard clinical practice in the UK. We believe that the same concerns apply to five studies from our review that were not included in the NICE guidance.[14,22–24,56]

In 2015, a survey about AMS in 421 hospitals from Asia, Africa, Europe, North America, Oceania and South America reported that testing for procalcitonin or other inflammatory markers was used to influence decisions about starting or stopping antibiotics in only 36% of hospitals.[2] In contrast, the majority of these hospitals used the other AMS interventions from our review: dissemination of guidelines (94%), review and recommendation for change in antibiotic therapy through telephone consultation (89%) or ward rounds (81%), audit (80%) and review of patients with bacteraemia (73%).

There are strengths and limitations to this review to consider. It is a review of studies included within an existing review rather than a systematic review of primary studies. This means that there may have been recently published AMS intervention studies that were not included in the Cochrane review and it is possible that recently conducted studies of AMS interventions have been reported more precisely in published reports. A strength of this review is in the application of an existing behavioural framework, TACTA, which has an established track record of application to reports of interventions[6] and a grounding in behavioural theory.[73] Other frameworks exist to encourage thorough descriptions of interventions and aid replication of studies, such as the TIDieR checklist.[74] However, the TIDieR checklist is focused on reporting of the details of intervention elements within a study rather than clearly specifying the behaviours that need to change as a result of the intervention. A behavioural approach using TACTA can add to reporting guidelines like TIDieR by increasing clarity and helping to operationalize the intervention elements themselves.[75]

Conclusions

The evidence that we have reviewed shows that actors and timing are poorly defined in AMS interventions to reduce unnecessary antibiotic prescribing in hospitals. This lack of specification is likely to hamper efforts to replicate successful interventions, synthesize evidence and implement successful interventions into practice. This lack of specification is particularly true for review of antibiotic treatment in continuing-care wards, where changing professional behaviour to influence antibiotic use is likely to be particularly challenging. There is a growing number of examples of theory-driven, systematic approaches to intervention design.[76,77] However, there is still a need to improve definition of problems in behavioural terms and improve understanding of current behaviour in context in order to maximize learning through evidence synthesis and detailed intervention reporting.[77] Studies reporting AMS interventions to reduce unnecessary antibiotic prescribing in hospitals should consider applying a behavioural framework to ensure that the evidence they provide can be used to help to build a picture of what works and that the *what*, *who*, *when*, *where*, *how often* and *with whom* of effective interventions can be operationalized into practice.

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Transparency declarations

None to declare.

Supplementary data

Tables S1 to S4 are available as Supplementary data at *JAC* Online

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